Globelics

Collaborative research in Brazil: differences between public and private sectors networks.

Renata Seldin, M.Sc.[1]
Anne-Marie Maculan, D.Sc[2]

1. Introduction

Literature on innovation and economic development shows that there are many ways of organizing one firm's innovative activities, especially those referred to research and development. R&D activities constitute an important source for innovation and can be carried out internally or externally through cooperative arrangements, such as networks. R&D networks, whether formal or informal, might be composed of a great array of actors, like private companies, government, universities and research institutes.

When looking at countries with more intense and consolidated R&D activities it is possible to identify the importance of the integration policies and incentive programs for public and private sectors to join efforts in collaborative research. The experiences of Australian Cooperative Research Centers (Liyanage, 1995), American Cooperative Research and Development Agreements (Miyata, 1996; Rogers et al., 1998; NSF, 2006; Munson & Spivey, 2006) and the European Framework Programmes (Dumont & Tsakanikas, 2001; Georghiou, 2001) illustrate this tendency.

Brazilian S&T policies have continually sought to create and boost research links between private and public sector (Velho *et al*, 2004), but the cooperation indicators for innovation are still insignificant. According to PINTEC, the Industrial Research on Technological Innovation conducted by the government, only 2.4% of participant firms answered they were involved in cooperative practices (IBGE, 2007).

Not to say that collaboration does not take place in the country. According to Grynzpan (2005), collaborative R&D programs are more and more common these days, linking private companies to universities, using corporate venture capital and underlining the interest on external knowledge appropriation in order to pursue in-house innovation. But,

[1] PEP/COPPE/UFRJ rseldin@ufrj.br

[2] PEP/COPPE/UFRJ
amaculan@pep.ufrj.br

with the data provided by PINTEC, it is still not possible to pin down the exact reasons why Brazilian firms engage so little in cooperation agreements.

The Brazilian government has made some efforts to stimulate network organizations. In the 90s, PADCT (a program to support scientific and technological development) aimed at encouraging collaborative research. In its third phase PADCT intends to contribute to the creation of an environment that fosters cooperation between the private sector and government, through the establishment and operation of partnerships funded by the program. It also proposes to qualify human capital in order to address both academy and industry's needs, besides better applying scientific technological knowledge to help national development (MCT, 1998).

The government's network support movement presented milestone with the RECOPE (Cooperative Research Networks) project, part of a bigger program aimed at the development of engineering in Brazil and sponsored by FINEP (a government financing agency). According to Longo (2004), RECOPE was one of the first national programs structured to exclusively support cooperative research that benefited the productive sector. Other governmental initiatives such as the creation of Institutos do Milênio (Institutes of the Millenium), during the third phase of PADCT can be pointed out but so far the program has released no performance reports.

In order to assess Brazilian research networks' organization and the results they have reached, a more detailed view of the country's current experience is needed. First, a definition of what we understand by "network" is offered, along with its main characteristics.

With those in mind we set out to investigate Brazilian experiences in collaborative research by initially presenting a collection of initiatives carried out by the government. We have collected preliminary data from RECOPE in order to provide an in depth look at one of the assessed initiatives. Data was collected from the final reports of the program.

With this first set of data it was possible to start looking at the Brazilian public x private sector dichotomy highlighting some of their main differences.

2. Literature on R&D networks

According to the Frascati Manual (OECD, 1994), R&D is one of the many activities that compose the innovative process. R&D is not only the initial source of ideas and inventions, but also responsible for solving problems in any of its other implementation phases.

When looking at the many R&D processes, a characteristic that strikes attention is the uncertainty regarding the achievement of the expected results (Kline & Rosenberg, 1986; Croisier, 1998). This uncertainty can be due to not achieving the expected result, not meeting deadlines, not being able to commercialize the results, etc. In sum, it means that R&D activities are risky and that should be taken into account when deciding how to engage in them.

It is also important to stress that the role of R&D in the organization is not just to generate new knowledge but also to absorb and transfer it, learning from the information that circulates (Lundvall & Johnson, 1994; Croisier, 1998; Jensen et al., 2007). According to Bercovitz & Feldman (2007), the balance between these functions is a strategic choice that has to be made by the firm. This choice is reflected in the organization of the R&D activities and in the way they deal with knowledge.

Many authors talk about the alternatives to organize R&D activities (Croisier, 1998; von Zedtwit et al., 2004; Bercovitz & Feldman, 2007). The first distinction made is between internal and external R&D. The first is conducted exclusively inside the firm, with no external intervention. The latter involves partnerships coordinated by contracts. As for the different forms of organizing external R&D, agreements can be unilateral (through subcontracting of specialized resources), bi or multilateral, where each part contributes with knowledge and/or resources (Croisier, 1998).

When contractual relations are simple and isolated, R&D can be decentralized and the boundaries of the organization are expanded to accommodate relations with third parties. On the other hand, if R&D projects are complex and need more coordination, R&D tends to be centralized and carried out internally. The organizational mode adopted by the firm is derived from its strategic choice of conducting research internally or buying knowledge generated externally. Between these two options, firms can choose to establish external ties and jointly generating knowledge by conducting collaborative research (Foray, 1991; Croisier, 1998; Gassmann & von Zedtwitz, 1999).

Chiesa (1996) presents a literature review on the *pros* and *cons* of centralizing the research activities. On the first case, the author cites the need to keep new technologies and knowledge in secret, the high costs of coordination and control of a more decentralized positioning and the presence of economy of scale. Decentralization's advantages include the need to acquire transferred technology, access to external markets, increased possibilities to respond to local demands and proximity to clients. The author also mentions the need to have access to more scientific and technological skills and knowledge and to recruit qualified human resources. The importance of external sources of knowledge is also mentioned by Nieto & Santamaría (2007).

a. Knowledge

By acknowledging the existence of external relations, we need to analyze the strategy adopted by the firms regarding the knowledge generated, acquired and used in these interactions. The literature points out two different approaches for the knowledge generated in collaborative research: exploration or experimentation and exploitation (March, 1991; Chiesa, 1996; Bercovitz & Feldman, 2007).

Exploitation means, according to March (1991) e Bercovitz & Feldman (2007), the refinement, extension and intelligent use of already existing competences. Knowledge exploration R&D activities are incremental and short-term and can be directly connected to the applicability of its expected results (Arranz & Arroyabe, 2007).

Exploration, on the other hand, concentrates on the search, discovery and development of new knowledge. This kind of action is highly associated with the uncertainties of the expected results. Activities in this category include long-term research project to develop new capabilities and product platforms (March, 1991).

Revilla et al. (2005) present a distinction between exploration and exploitation by associating the first to basic research and the latter to applied research. It is important to say that the literature itself admits that this kind of differentiation can be ambiguous (Mezias & Glynn, 1993 apud Revilla et al., 2005) and that most R&D projects require some generation of new knowledge and the application of existing knowledge.

b. Collaboration

Collaboration in R&D activities can be defined as the union of two or more parts, institutions or individuals, jointly seeing to achieve a common goal (Arranz & Arroyabe, 2008).

The literature presents many reasons why actors should cooperate, such as faster time-to-market, lower costs and risks, access to financial capital, etc, as seen in the table below.

Benefíts	References
Cost reduction in technological development or market entry	Hagedoorn (1993); Longo & Oliveira (2000); Hagedoorn et al (2000); Tidd, Bessant & Pavitt (2005); Arranz & Arroyabe (2008)
Risk reduction/ uncertainty reduction:developmento or market entry	Hagedoorn (1993); Eisenhardt & Schoonhoven (1996); Longo & Oliveira (2000); Hagedoorn et al (2000); Gulati et al (2000); Tidd, Bessant & Pavitt (2005); Revilla et al (2005); Arranz & Arroyabe (2008)
Transaction costs reduction	Hagedoorn et al (2000); Arranz & Arroyabe (2002); Solleiro & Castañón (2005)
Resource complementarity or sharing	Chiesa (1996); Longo & Oliveira (2000); Hagedoorn et al (2000); Arranz & Arroyabe (2002); Arranz & Arroyabe (2008)
Time reduction to develop and commercialize new products	Hagedoorn (1993); Eisenhardt & Schoonhoven (1996); Longo & Oliveira (2000); Tidd, Bessant & Pavitt (2005); Arranz & Arroyabe (2008)
Economy of scale	Hagedoorn (1993); Hagedoorn et al (2000); Gulati et al (2000); Tidd, Bessant & Pavitt (2005)
Access to financial capital	Arranz & Arroyabe (2008)
Access to knowledge and new competencies	Hagedoorn (1993); Eisenhardt & Schoonhoven (1996); Chiesa (1996); Gulati et al (2000); Revilla et al. (2005)
Access to market	Hagedoorn (1993); Eisenhardt & Schoonhoven (1996); Hagedoorn et al (2000); Gulati et al (2000)
Learning capacity improvement	Eisenhardt & Schoonhoven (1996); Hagedoorn et al (2000); Gulati et al (2000); Tidd, Bessant & Pavitt (2005); Revilla et al (2005); Arranz & Arroyabe (2008)
Technological transfer	Hagedoorn (1993); Hagedoorn *et al* (2000)

Arranz & Arroyabe (2008) say that the alliance between partners allows for a combination of fidelity programs, more legitimacy and trust and better reputation for those involved.

Gulati et al. (2000:204) say that a "firm's network of relationships is a source of both opportunities and constraints", because regardless of the benefits mentioned above, firms can be stuck in unproductive relations and unable to engage in more viable ones. Hagedoorn et al. (2000) present two main reasons why cooperation agreements fail: different strategic visions and management difficulties.

The search for increased productivity and better competitive performance intensifies the firm's need for economies of scale, risk sharing and exploring complementary assets. This constant search leads to the development of new organizational formats that cross the firms' boundaries, in the form of collaborative actions and interactions (Teece, 1986). Many studies show the importance of these interactions as external sources of technological expertise, contributing to the improvement of productivity and competitive performance through innovation, especially in R&D (Freeman, 1991; Solleiro & Castañón, 2005).

To Freeman (1991), successful innovations present links between producers and consumers (also mentioned by Lundvall, 1988), integration of internal activities such as development, production and marketing, and the links with external sources of technical and scientific information. These factors are characterized by the author as formal and informal networks, even though he highlights that the word "network" is not necessarily the best fit.

c. Definitions

In order to move forward in our research, it was necessary to define the word "network". Many authors offer definitions for this term. According to DeBresson & Amesse (1991), the concept is used for different purposes, from groups of individuals in a research project to innovative firms working together. They argue that "networks of innovators are relatively loose, informal, implicit, decomposable and recombinable systems of inter-relationships" (p. 364). Bianchi & Bellini (1991:489) define network as "an interactive set of firms, based on an external division of labor, which is not directed by hierarchical command". Gulati (1998:293) starts his work on networks by defining "strategic alliances" as "voluntary arrangements between firms involving exchange, sharing or co-development of products, technologies or service" and adds that those alliances can form networks.

For the purposes of this work, networks are considered to be more than just dyadic, bilateral relations, with different intensities. Our intent is to analyze Brazilian networks based on their nature, configuration and content of relationships. When it comes to research networks, the definition adopted will be the same used by Arranz & Arroyabe: a set of cooperation agreements and partnerships by independent organizations searching for a common technological project (Fernandez-Arroyabe & Arranz, 2002; Arranz & Arroyabe, 2006, 2008).

The importance of a common goal is also mentioned by Bianchi & Bellini (1991) and Longo & Oliveira (2000). Hellström et al. (2001) say that research networks are created

and maintained by a number of actors that jointly seek for answers to problems and that are mutual dependent.

In an attempt to simply the definition, we could say that these agreements (A) are characterized by the players (p) involved (quantity and kind), by the allocated resources (time, capital and knowledge), the type of activity (a) developed (basic research, applied research, etc) and the objectives (o) pursued. What follows is that an agreement *i* is a function of *y* kind of actors *j* and the resources *r*, that carry out the activity *a* in order to achieve the objective *o.*In other words:

$$A_i = f\left(\sum_{j=1}^{m}\sum_{y=2}^{n} p_{j,y}\ ,\ r\,(t,\ c,\ K_{x,j,y}),\ a_i,\ o_i\right)$$

Some possibilities of actors *j* are universities, labs, research centers, firms, hybrid organizations, non-profit organizations, consulting firms, politician, venture capitalists, etc (Gilbert et al., 2001; Hellström et al., 2001; Arranz & Arroyabe, 2006, 2008).

By understanding a research network as a set of technological agreements, it is possible to define a network (R) as the sum of agreements (A), that is:

$$R = \sum_{i=1}^{n} A_i$$

Many researchers and authors have already worked on the elements of R&D networks, for example: objectives of the network, type of R&D activity being carried out (invention, innovation and/or diffusion), coordination, control and safeguard mechanisms, embeddedness structure, openness, formality, frequency and intensity of contacts. Some of these authors are Arranz and Arroyabe (2002, 2006, 2007), Gassmann and von Zedtwitz (1999), Gulati (1998, 2000), Lundvall (1988) and Jones et al. (1997).

Hence, network analysis should consist not only by the agreements that compose them, but also by their governance, identifying their structural and safeguard mechanisms and their social aspects.

It is also possible to highlight an ever present characteristic of complexity associated to the term "network". Fernandez-Arroyabe & Arranz (2002) attribute this complexity to the exchange of knowledge, resources complementarities, multiple interactions, heterogeneity of structures and conflicts of interest that are present in networks.

The knowledge exchange in a network increases complexity. Because they are intangible assets, information and knowledge can be seen as competitive differentials. So, in an exchange relation established in a network, the capacity to develop, broadcast and internalize knowledge is a complex phenomenon and it is influenced by external and internal factors (uncertainty and experience, for example).

Bercovitz & Feldman (2007) argue that partner selection is connected to the kind of treatment given to knowledge. When the intention is to increment already existing

knowledge, there is a tendency to value the complementarity of partners. On the other hand, when exploring new knowledge is the main objective, partner diversity is valued. Arranz & Arroyabe (2008) also discuss the difficulties of partner selection in collaborative projects.

In his work of 1998, Croisier (1998) emphasizes the differences in internal and external R&D. In the first case, all the activities are conducted inside the firm, with no external intervention while in the second case there is a contract between the parts involved. He also says that there are different organizational formats for external R&D and they vary according to the uncertainty of the Project, frequency of interactions and specificity of the achieved results.

Jones et al. (1997) also highlight these three environmental conditions that determine the most efficient governance form for a network: uncertainty, specificity and frequency. The first two are mentioned by Williamson (2002) as relevant factors in the definition of the governance model. Arranz & Arroyabe (2007) add applicability and appropriation of results to the list. The authors offer a table that relates these conditions in order to define network governance:

Market				Hierarchy
-	←	Uncertainty	→	+
-	←	Specificity	→	+
-	←	Frequency	→	+
-	←	Appropriation	→	+
-	←	Applicability	→	+

They also connect the conditions above with the activities carried out in the networks and their objectives:

Applicability	Activities	Objectives
High ↓ Low	▪ Product development ▪ Applied research ▪ Pre-commercial applied research ▪ Basic research	▪ New products ▪ Patents ▪ Trainning ▪ Research and resources databases ▪ Scientific publications

Following this path, it is possible to make a parallel between the applicability of R&D activities (whether carried out internally or externally) and the kind of knowledge treatment applied (exploration or exploitation).

R&D concentration	Applicability	Knowledge treatment	Activity	Objectives

Internal ↓ External	High ↓ Low	*Exploitation* ↓ *Exploration*	▪ Product development ▪ Applied research ▪ Pre-commercial applied research ▪ Basic research	▪ New products ▪ Patents ▪ Training ▪ Research and resources databases ▪ Scientific publications

Arranz & Arroyabe (2007) argue that, according to the project characteristics (especially the applicability of the results), it is possible to identify the best form of governance. That means that when analyzing a network, one should not only look to the set of agreements but also to the form of governance. In the following section we discuss the Brazilian experiences with research networks and analyze a particular case in order to assess the difference between networks in the public and private sectors.

3. Brazilian experiences with research networks

In Brazil, the industrialization process was characterized by imports of technology, low technological development capacity and low investment in R&D. Both the protectionism and the dependency on technology transfer are factors that can be found in the origins of the low innovative capacity of the firms. With no R&D activities, the Brazilian firms were restricted to accumulating specific capabilities to operate the imported technologies and to adapt them to the local needs. A very similar scenario could be found in other countries that experienced the late industrialization process (Meyer-Stamer, 1995; Bell & Albu, 1999; Viotti, 2002).

When the Ministry of Science and Technology (MCT) was created in 1985 and after the economic opening in 1990, governmental actions regarding S&T were revised in an attempt to address industrial demands with the knowledge that was generated by universities and research centers. Salerno (2004) argues, though, that governmental programs were disperse and unable to stimulate a real change in the competitive position of the Brazilian industry. The productive processes became more efficient but the competitive focus was still on organizational and/ or incremental innovations in the factories and not on other functions such as R&D, product projects and conceptions, distribution, international branding, etc (Meyer-Stamer, 1995; Salerno, 2004).

Governmental initiatives to stimulate interaction and collaboration between industry, universities and research center were present in PADCT - Programa de Apoio ao Desenvolvimento Científico e Tecnológico (a program to support the scientific and technological development) in the end of the 80's (MCT, 1998). Currently in its third edition, PADCT seeks the creation of a cooperative environment for both private and public sectors by establishing and operating partnership agreements. Another goal is to help the formation of human capital to address the demands of both the academy and industry. Sadly, we found no formal indicators that could prove its relevance, efficiency or efficacy in reaching those goals.

The support of academic research networks in the country had a milestone in 1995 when program RECOPE (Redes Cooperativas de Pesquisa – Cooperative Research Networks)

was launched, as part of FINEP's Prodenge (a program for the development of engineering) initiative. According to Longo (2004), it was one of the first national programs structured to specifically support cooperative networks that addressed the productive sector.

Other projects and programs can be found in the recent history of S&T in Brazil. The table below presents a brief description of each of them.

Initiative	Objectives	Year	Investment (million R$)	Source
Projeto Ômega	Stimulate cooperative research projects, led by research centers, universities or technological institutes, public or private	1996	2	Presidência da República (1998) Velho et al (2004)
Recope	Financial support to the formation of cooperative networks and to already existing networks willing to act on specific terms regarding engineering	1996	25	FINEP (2003)
CDT (Plataformas)	Establish proposals to develop cooperative technological projects aiming the technological advance of the country. Estabelecer propostas para projetos	1999	4,2*	Terra & Plonski (2006) Site MCT[3]
CDT (Projetos Cooperativos)	Assist the productive sector during initial technological development phases.	1999	142,8*	Site MCT[4]
Institutos do Milênio	Sponsor scientific research in strategic areas for the development of the country.	2001	90	Site do CNPq
Projetos cooperativos do Fundo Verde-Amarelo	Stimulate innovation cooperative projects to be carried out by the productive sector together.with R&D institutions	2001	146,5	CGEE (2002)

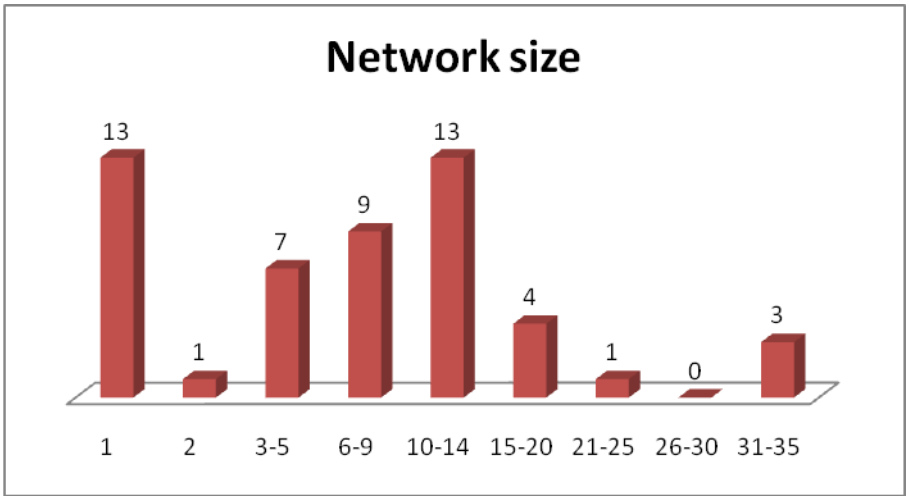
* US$

So far we have seen the Brazilian experiences in cooperative research that were motivated by the government. It is harder to find data about the collaborative research in the Brazilian private sector. Firstly because Brazilian firms engage very little in R&D activities, and consequently the possibility of engaging in cooperative practices is also small. Secondly, engaging in research networks is considered to be a strategic decision of the firm, which increases the confidentiality of this kind of data.

In order to verify how Brazilian research networks are organized and which results they produce we need to dig deeper in the collaboration issue. To do so we based our study in the RECOPE program, that was constituted by networks with governmental organizations and private companies.

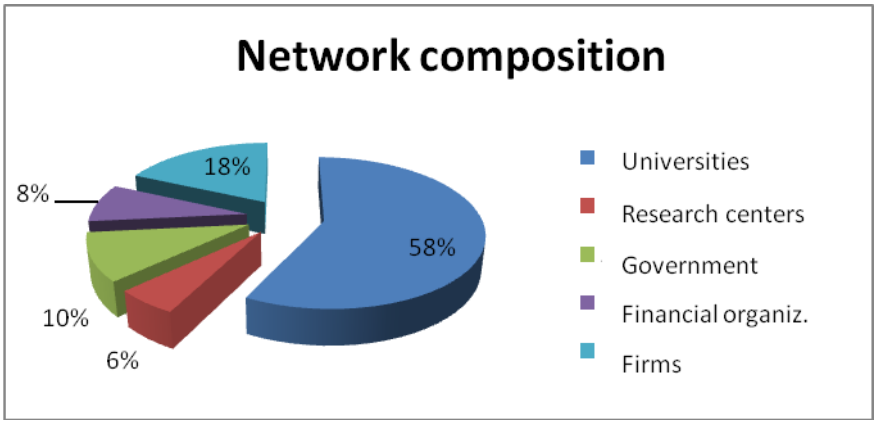
The program was divided in 7 themes and 24 networks. Some of the networks were separated into projects or smaller groups, making it a total of 40 arrays of players, considered as our unit of analysis (networks). Network size and composition were assessed because they impact the complexity of coordination. Network size ranged greatly, as shown in the graphic below.

[3] Available at http://200.130.9.7/prog/padct/PADCT_III/Financiamento.htm



One of the first issues we need to address is the number of networks consisted of a single player. By the definition adopted earlier, they should not be considered as networks. A closer look shows that these cases consist of research groups, mostly from the sub-division of the networks into projects. Judging by the definition presented in this paper, the program failed to unite different actors in search of a common goal.

Network composition is also an important issue. From the 40 networks, 47.5% were composed solely by universities and research centers. Other actors were firms, government and financial organizations. The following graphic shows the average network composition in terms of type of actor.

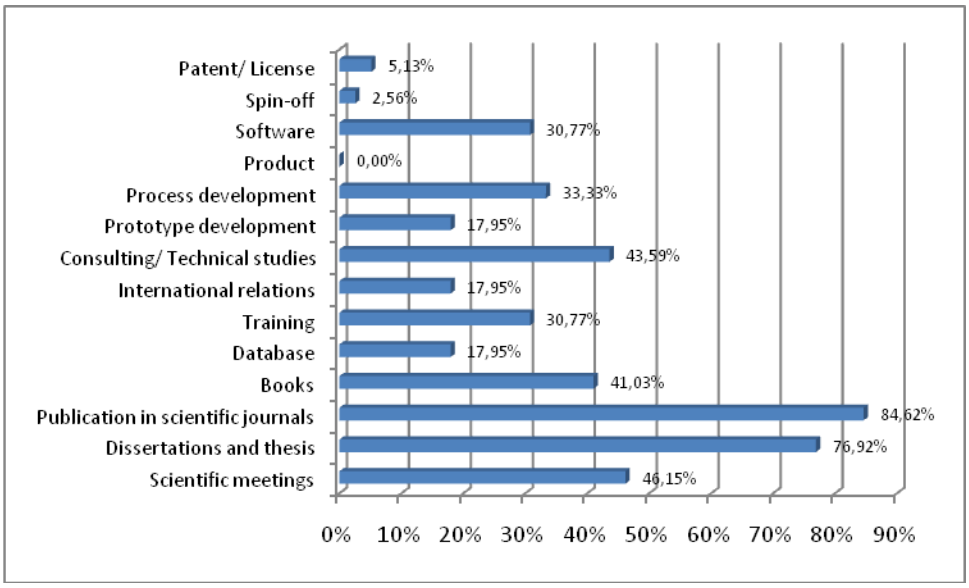


In terms of achieved results we can divide them according to the type of project, as suggested by Arranz & Arroyabe (2006). Invention projects seek the creation of new knowledge and result in patents. Innovation projects are composed by activities such as discovering market needs, generating ideas, product developing, manufacturing and introducing products in the market. The third and last type of Project is diffusion, which activities include the publication of scientific papers, research databases and training.

In the table below, the results achieved in the RECOPE projects, as listed in the final report of FINEP (2003), are divided between invention, innovation and diffusion.

Scientific meetings Dissertations and thesis Publication in scientific journals Books Databases Training International relations	Consulting work Technical studies Prototype development Process development Software Spin-off	Patents Licenses

The initial goal of each network was not available, so it is hard to say whether or not they achieved the expected results. The following graphic shows the frequency in which each result was observed.



The results can be explained by taking into account the context where they were produced. Universities and research centers, the most representative actors in the networks, have as one of their major functions, the diffusion of knowledge, which explains the great number of scientific publications, books, dissertations and thesis.

By cross-referencing network size and composition with the results achieved we can say that networks with a greater number of firms produce more innovation results. Data from RECOPE also allows a first analysis on the elements that compose the definition of network presented in this paper. Information on network size and composition represents the first part of the equation:

$$f\left(\sum_{j=1}^{m}\sum_{y=2}^{n} p_{j,y}\right)$$

Data about the resources, referring to the second part of the equation, r (t, c, $K_{x,j,y}$), was not available. Still, it is important to highlight that experience built from previous participations in network arrays plays a big role in networks (Nieto & Santamaría, 2007). In our equation, this experience is reflect in $K_{x,j,y}$ where x is the experience added to the knowledge K by the

actor *y* which is the kind *j*. Data available from RECOPE did not allow us to evaluate actors' experience either.

The results achieved in each network were not exhaustive, but they give us a first glimpse on the functions activity $f(a_i)$ and objectives $f(o_i)$, complementing the proposed equation.

When comparing the networks in RECOPE, separating public and private experiences, we find some contrasts, presented below.

	Public sector (university/research center)	Private sector (firms)
Motivation	External (government)	Intern
Objective	Create or further knowledge	Competitive advantage
Main activities	Basic/ applied research	New product/ process development
Main results	Scientific publications	Products

These results show that the public sector seeks to create and further new knowledge through basic and applied research (knowledge exploration). Its main motivation comes from the government and the results are often seen in scientific publication. Private companies, on the other hand, seek competitive advantage through new product/ process development (knowledge exploitation).

4. Conclusion

This paper objective was to tackle the subject of collaborative research experiences in Brazil. In order to understand how Brazilian research networks are organized and the results they have obtained, we have collected preliminary data from RECOPE, a governmental initiative aimed at the engineering science.

In terms of results obtained by the networks, it was possible to separate them in: invention, innovation and knowledge diffusion. Data showed a great concentration of scientific publication, typical production of the academia which amongst its function is the diffusion of knowledge. Other observed results were technical studies and consultancy.

By cross-analyzing networks size and composition with their obtained results it appears as though networks with a greater number of private firms produce more results in the innovation category (which involves patents and licenses).

With this first set of data it was possible to start looking at the Brazilian public x private sector dichotomy. Apparently, the public sector seeks to create and further new knowledge through basic and applied research (knowledge exploration). Its main motivation comes from the government and the results are often seen in scientific publication. Private companies, on the other hand, seek competitive advantage through new product/ process development (knowledge exploitation).

The theme "research networks" is current and relevant, not only for firms to better position themselves competitively but also for the definition of efficient public policies that stimulate the R&D collaboration between public and private sectors. It is important to understand how Brazil carries out its research activities.

These preliminary results are not exhaustive but shed some light on the propositions concerning the network function proposed. The collected data was not enough to infer about network governance.

We suggest furthering this investigation by conducting case studies in hope they will provide unprecedented information on the organization and impacts of Brazilian R&D organization. By understanding how the many network characteristics described in the literature can be combined resulting in different organizational forms, and hence governance structures, we are might be able to suggest a framework to be used in the planning of new R&D networks, minimizing the period of trial and error that normally precedes the success of the collaboration.

5. References

ARRANZ, N. & ARROYABE, J.C.F. (2008) The choice of partners in R&D cooperation: An empirical analysis of Spanish firms. **Technovation** 28, pp. 88-100.

ARRANZ, N. & ARROYABE, J.C.F. (2007) Governance structures in R&D networks: An analysis in the European context. **Technological Forecasting & Social Change** 74 (5), pp. 645-662

ARRANZ, N. & ARROYABE, J.C.F. (2006) Joint R&D projects: Experiences in the context of European technology policy. **Technological Forecasting & Social Change** 73 (7), pp. 860-885.

ARRANZ, N. & ARROYABE, J.C.F. (2002) **Business cooperation: From theory to practice**. New York: Palgrave Macmillian.

BELL, M. & ALBU, M. (1999) Knowledge Systems and Technological Dynamism in Industrial Clusters in Developing Countries. **World Development** 27 (9), pp. 1715-1734.

BERCOVITZ, J.E.L. & FELDMAN, M.P. (2007) Fishing upstream: firm innovation strategy and university research alliances. **Research Policy** 36, pp. 930–948.

BIANCHI, P. & BELLINI, N. (1991) Public policies for local networks. **Research Policy** 20, pp.487-497.

CGEE (2002) **Fundo Verde-Amarelo: Balanço das ações em 2002**. Secretaria Técnica do Fundo Verde-Amarela e Centro de Gestão e Estudos Estratégicos. CGEE/FVA Brasilia, 16 de dezembro de 2002.

CHIESA, V. (1996) Managing the internationalization of R&D activities. **IEEE Transactions on Engineering Management** 43 (1), pp. 7-23.

CROISIER, B. (1998) The governance of external research: empirical test of some transaction-cost related factors. **R&D Management** 28 (4), pp. 289-298.

DUMONT, M. & TSAKANIKAS, A. (2001) Knowledge spillovers through R&D networking. **OECD - Directorate for Science, Technology and Industry**. Available in: http://www.oecd.org/dataoecd/33/50/2096950.pdf

EISENHARDT, K. & SCHOONHOVEN, C. (1996) Resource-Based View of Strategic Alliance Formation: Strategic and Social Effects in Entrepreneurial Firms**. Organization Science** 7 (2), pp. 136-150.

FERNANDEZ-ARROYABE, J.C. & ARRANZ, N. (2002) Principles for the design of management control systems in knowledge networks: Experiences involving the European technology networks. **Technological Forecasting & Social Change** 69, pp. 703-719.

FINEP (2003) **RECOPE – Redes Cooperativas de Pesquisa. Relatório do Seminário de Avaliação Final do Programa RECOPE**. Rio de Janeiro.

FORAY, D. (1991) The secrets of industry are in the air: Industrial cooperation and the organizational dynamics of the innovative firm. **Research Policy** 20, pp. 393-405.

FREEMAN, C. (1991) Network of innovators: A synthesis of research issues. **Research Policy** 20, pp. 499-514.

GASSMANN, O. & von ZEDTWITZ, M. (1999) New concepts and trends in international R&D organization. **Research Policy** 28, pp. 231-250.

GEORGHIOU, L. (2001) Evolving frameworks for European collaboration in research and technology. **Research Policy** 30, pp. 891–903.

GILBERT, A., PYKA, A. & AHRWEILER, P. (2001) Innovation networks – a simulation approach. **Journal of Artificial Societies and Social Simulation** 4 (3).

GRYNZPAN, F. (2005). Pesquisa e desenvolvimento nas empresas multinacionais do Brasil. **Revista Parcerias Estratégicas**, n. 20, v.4.

GULATI, R., NOHRIA, N. & ZAHEER, A. (2000) Strategic networks. **Strategic Management Journal** 21, pp. 203-215.

GULATI, R. (1998) Alliances and networks. **Strategic Management Journal** 19 (4), pp. 293-317.

HAGEDOORN, J., LINK, A. & VONORTAS, N. (2000) Research partnerships. **Research Policy** 29, pp. 567-586.

HAGEDOORN, J. (1993) Understanding the rationale of strategic technology partnering: interorganizational modes of cooperation and sectoral differences. **Strategic Management Journal** 14 (5), pp. 371-385.

HELLSTRÖM, T., ECKERSTEIN, J. & HELM, A. (2001) R&D management through network mapping: using the internet to identify strategic network actors in cooperative research networks. **R&D Management** 31 (3), pp. 257-263.

IBGE – Instituto Brasileiro de Geografia e Estatística (2007) **Pesquisa Industrial de Inovação Tecnológica 2005**. Rio de Janeiro.

JENSEN, M.B., JOHNSON, B., LORENZ, E. & LUNDVALL, B-A. (2007) Forms of knowledge and modes of innovation. **Research Policy** 36, pp. 680-693.

JONES, C., HESTERLY, W.S. & BOGARTTI, S.P. (1997) A general theory of network governance: exchange conditions and social mechanisms. **Academy of Management Review** 22 (4), pp. 911-945.

KLINE, S.J. & ROSENBERG, N. (1986) An overview of innovation. In: Rosenberg, N. & Laudan, R. (eds) **The positive sum strategy**. Washington, DC: National Academy Press.

LIYANAGE, S. (1995) Breeding innovation clusters through collaborative research networks. **Technovation** 15 (9), pp. 553-567.

LONGO, W.P. (2004) O programa de desenvolvimento das engenharias. **Revista Brasileira de Inovação** 3 (2), Julho/ Dezembro.

LONGO, W.P. & OLIVEIRA, A.P (2000) Redes cooperativas e centros de excelência. **Parcerias Estratégicas** 9, pp. 129-144.

LUNDVALL, B-A. (1988) Innovation as an interactive process: from user-producer interaction to the national system of innovation. In: Dosi, G. et al. **Technical Change and Economic Theory**. London: Pinter.

LUNDVALL, B-A. & JOHNSON, B. (1994) The learning economy. **Journal of Industrial Studies** 1 (2), pp. 23-42.

MARCH, J.G. (1991) Exploration and exploitation in organizational learning. **Organization Science** 2 (1), pp. 71-87.

MCT – Ministério da Ciência e Tecnologia (1998) **Programa de Apoio ao Desenvolvimento Científico e Tecnológico – PADCT III – Documento Básico**. Disponível em: http://ftp.mct.gov.br/prog/padct

MEYER-STAMER, J. (1995) New departures for technology policy in Brazil. **Science and Public Policy** 22 (5), pp. 295-304.

MEZIAS, S. J. & GLYNN, M.A. (1993) The three faces of corporate renewal: institution, revolution, and evolution. **Strategy Management Journal** 14, pp. 77–101.

MIYATA, Y. (1996) An analysis of cooperative R&D in the United States. **Technovation** 16 (3), pp.123-131.

MUNSON, J.M. & SPIVEY, W.A. (2006) Take a portfolio view of CRADAS. **Research Technology Management** 49 (4), pp. 39-45.

NSF – National Science Foundation (2006) **Science and Engineering Indicators 2006.** US Government Printing Office, Washington DC.

NIETO, M.J. & SANTAMARÍA, L. (2007) The importance of diverse collaborative networks for the novelty of product innovation. **Technovation** 27, pp. 367-377.

OECD (1994) **Proposed Standard Practice for Surveys on Research and Experimental Development - Frascati Manual 1993**. The Measurement of Scientific and Technological Activities Series, Paris.

PRESIDENCIA DA REPUBLICA (1998) "Nova política industrial: desenvolvimento e competitividade". Brasília. Acessado em Abril/2008. Disponível em: http://www.planalto.gov.br/publi_04/colecao/novpoli.htm

REVILLA, E., SARKIS, J & ACOSTA, J. (2005) Towards knowledge management and learning taxonomy for research joint ventures. **Technovation** 25 (11), pp. 1307-1316.

ROGERS, E.M., CARAYANNIS, E.G., KURIHANA, K. & ALLBRITTON, M.M. (1998) Cooperative research and development agreements (CRADAs) as technology transfer mechanisms. **R&D Management** 8 (2), pp. 79-88.

SALERNO, M.S. (2004) A política industrial, tecnológica e de comércio exterior do governo federal. **Revista Parcerias Estratégicas** 19, pp. 13-36.

SOLLEIRO, J.L & CASTAÑÓN, R. (2005) Competitiveness and innovation systems: the challenges for Mexico's insertion in the global context. **Technovation** 25, pp. 1059-1070.

TEECE, D., PISANO, G. & SHUEN, A. (1997) Dynamic capabilities and strategic management. **Strategic Management Journal** 18 (7), pp. 509-533.

TEECE, D. (1986) Profiting from technological innovation: implications for integration, collaboration, licensing and public policy. **Research Policy** 15, pp. 285-305.

TERRA, B.C. & PLONSKY, G.A. (2006) Metodologias para Formação de Redes de Desenvolvimento – Um Estudo Benchmarking da Regional Innovation System – RIS, na União Européia - UE e das Plataformas Tecnológicas – PLAT, no Brasil. In: **XXIV Simpósio de Gestão da Inovação Tecnológica - Inovação em Redes & Redes de Inovação**, 2006, Gramado, RS – Brasil.

TIDD, J., BESSANT, J. & PAVITT, K. (2005) **Managing innovation: integrating technological, market and organizational change**. 3rd edition. West Sussex: John Wiley & Sons.

VELHO, L., VELHO, P. & SAENZ, T.W. (2004) P&D nos Setores Público e Privado no Brasil: Complementares ou Substitutos? **Revista Parcerias Estratégicas** 19, pp. 87-128.

VIOTTI, E. B. (2002) National Learning Systems: A new approach on technological change in the late industrializing economies and evidences from the cases of Brazil and South Korea. **Technological Forecast & Social Change** 69 (7), pp. 653-680.

VON ZEDTWITZ, M., GASSMANN, O. & BOUTELLIER, R. (2004) Organizing global R&D: challenges and dilemmas. **Journal of International Management** 10, pp. 21-49.

WILLIAMSON, O.E. (2002) The theory of the firm as governance structure: from choice to contract. **Economic Perspective** 16 (3), pp.171-196.